Defense Technical Information Center
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This paper is a part of the following report:

• *Title:* Technology Showcase: Integrated Monitoring, Diagnostics and Failure Prevention.

   Proceedings of a Joint Conference, Mobile, Alabama, April 22-26, 1996.

• *To order the complete compilation report, use:* AD-A325 558

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EXPERT - EXAMINATION COMPUTER SYSTEM FOR ESTIMATING OPERATIONAL STATUS OF TECHNICAL EQUIPMENT WITH ACCOUNTING FOR THE RELIABILITY OF ITS LIFE-CRITICAL PARTS

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Abstract: The paper describes the principles of creating the expert-examination computer system for estimating the operational status of technical equipment which, on the basis of generalizing a multi-year experience in operating aeronautical and other engineering with the use of the metallophysical analysis methods, enables making conclusions on the causes of the wear and breakdowns of machine parts and structural members as well as predicting potential failures and choosing the best suited flaw detection method for similar technical equipment.

The on-condition operation and repair of technical equipment call for developing a package of techniques, criteria and associated means which would provide the distinct and credible in-operation detection of defects in life-limiting parts and units of concrete machines. In many cases these techniques and means are immediately connected with the peculiarities of operating concrete technical equipment and must be continuously upgrading as an operational experience is gained and the equipment itself is renewed. All this demands the availability and regular replenishment of a corresponding database as well as the development of algorithms for forming standardized expert decisions on the status of technical equipment and the causes of its wear, failure or breakdown based on the impartial information acquired during its monitoring. With this in mind an expert-examination system was created for examining operational status of technical equipment which was developed on the basis of the analysis and generalization of the results of a large body of investigations of faulty and failed aviation and other materiel.

For the initial information required for running the expert-examination computer system to be obtained, one uses methodological procedures, criteria, portable flaw-detection and other material-testing instruments which make possible to reveal in proper time the pre-failure status of machine parts and to identify the causes of their wear and breakdown.

The expert-examination computer system is multifunctional. Through an interactive dialog of a user with the computer, it

enables:
     estimating the status of life-critical machine parts;
     receiving a conclusion on the causes of the wear and breakdown of parts and structural members;
     offering the best acceptable flaw-detection method for similar technical equipment;
     estimating, in a number of cases, a residual life.

The estimation of the technical status of a part or structural member with the aid of the expert system is accomplished through an operator-computer dialog. In response to computer's query, the operator enters available inspectorial data on the objective indications recognized of changing physical and mechinical properties of the material which allow predicting possible failures of the parts and joints under examination.

In the case of the part breakdown, the inspectorial information is to be entered according to the following divisions:
     features of the macro- and microrelief of the failure surface;
     features of the fracture;
     peculiarities of developing plastic deformation;
     peculiarities of part's loading;
     quality of welding and assembling the part or structure;
     operational conditions.

Each of the divisions indicated consists of smaller and more specialized groups, each including in turn a set of indications characterizing the part status. For example, included in the division for features of the macro- and microrelief of the failure surface are the following six indications:
     microrelief of the failure surface (fracture);
     microrelief of the failure nucleation site;
     microrelief of the zone of gradual crack propagation;
     microrelief of the fracture of homogeneous structure or the zone of gradual crack propagation (failure);
     macrorelief of the zone of accelerated crack propagation;
     macrorelief of the rupture zone.
Each of these groups contains 10-20 indications.

It is just the formulation of the set of indications of various types characterizing the status of a part or structural member that was one of the most important and complex problems in developing the expert-examination computer system. Another problem of great importance was to form such aggregates from these set of indications which would allow predicting a failure and, if a breakdown has occured, uniquely characterizing the kind of the fracture and identifying its cause.

The stationary database of the expert-examination computer system contains a great body of data, gained in many years of operating aeronautical and other equipment, on appearance status, matarial quality, assembly quality, operational conditions of parts, units and structures.
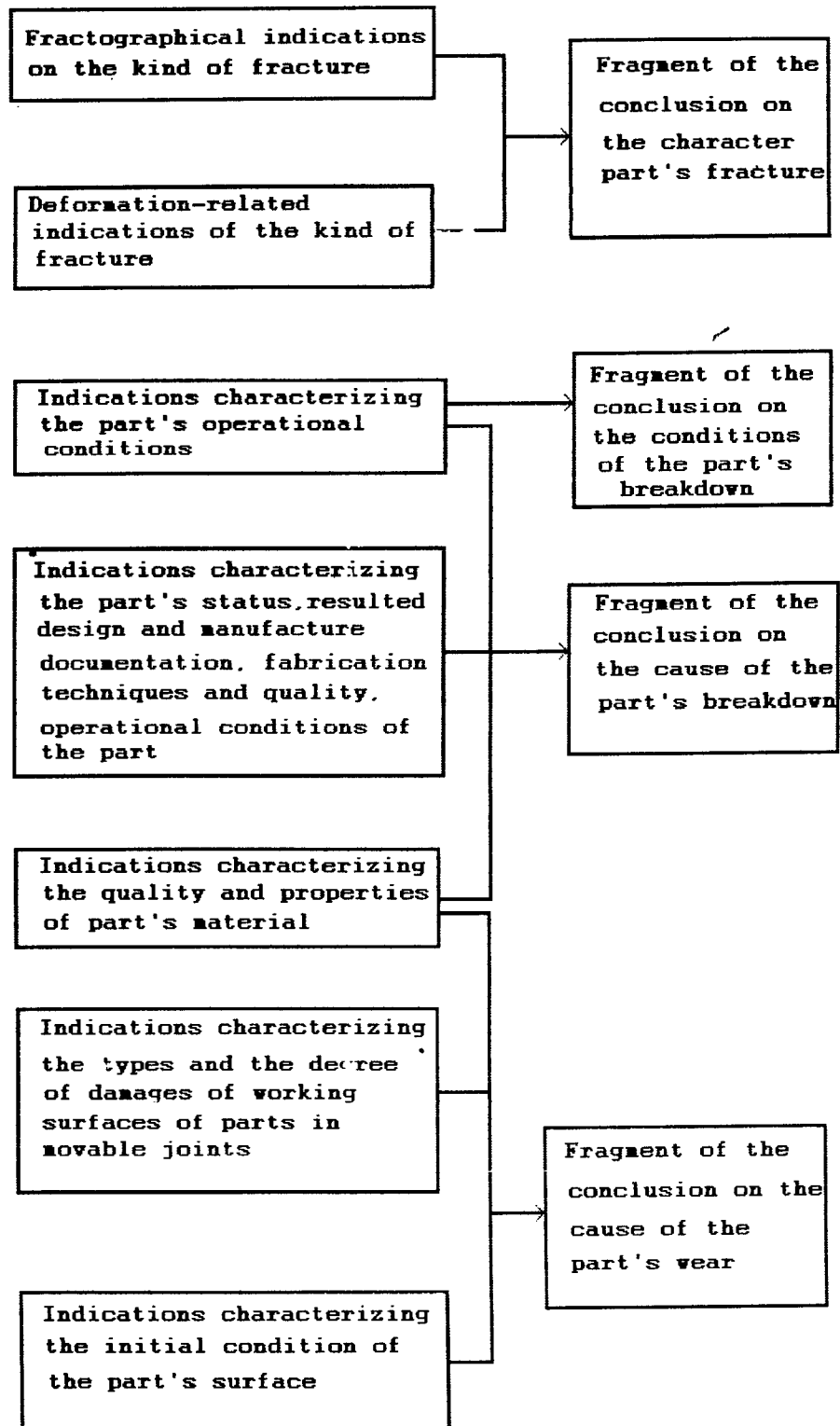
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┌────────────────────────────┐        ┌────────────────────┐
│ Fractographical indications│        │ Fragment of the    │
│ on the kind of fracture     │──────┐ │ conclusion on      │
└────────────────────────────┘      │ │ the character      │
                                     ├─▶│ part's fracture    │
┌────────────────────────────┐      │ └────────────────────┘
│ Deformation-related         │      │
│ indications of the kind of  │──────┘
│ fracture                    │
└────────────────────────────┘

┌────────────────────────────┐        ┌────────────────────┐
│ Indications characterizing  │──────▶ │ Fragment of the    │
│ the part's operational      │        │ conclusion on      │
│ conditions                  │        │ the conditions     │
└────────────────────────────┘        │ of the part's      │
                                        │ breakdown          │
                                        └────────────────────┘

┌────────────────────────────┐        ┌────────────────────┐
│ Indications characterizing  │        │ Fragment of the    │
│ the part's status,resulted  │        │ conclusion on      │
│ design and manufacture      │──────▶ │ the cause of the   │
│ documentation, fabrication  │        │ part's breakdown   │
│ techniques and quality,     │        └────────────────────┘
│ operational conditions of   │
│ the part                    │
└────────────────────────────┘

┌────────────────────────────┐
│ Indications characterizing  │
│ the quality and properties  │
│ of part's material          │
└────────────────────────────┘

┌────────────────────────────┐
│ Indications characterizing  │
│ the types and the degree    │
│ of damages of working       │        ┌────────────────────┐
│ surfaces of parts in        │        │ Fragment of the    │
│ movable joints              │        │ conclusion on the  │
└────────────────────────────┘──────▶ │ cause of the       │
                                        │ part's wear        │
┌────────────────────────────┐        └────────────────────┘
│ Indications characterizing  │
│ the initial condition of    │
│ the part's surface          │
└────────────────────────────┘
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Fig.1 Sheme of forming a conclusion on the
      character, conditions and cause of
      the pert breakdown

All these data are stored in definite combinations which are referred to as "standards". Each standard characterizes a concrete cause of failure, wear or breakdown of a piece of machinery.

The comparison of inspectorial information, that is, the data obtained during the monitoring or examination of a failed (broken down) part, with the standards stored in the stationary database is executed by the computer according to a special program.

The variants of standardized conclusions produced by the expert system, can have different numbers in the priority list depending on the number of absent (not obtained during inspection) data and the number of disagreements between inspectorial data and the information (combination of indications and actual data) of the standard chosen by the system. The variant of expert decision having the highest rank corresponds to the minimum number of disagreements with a standard is always the most preferable. But the analysis of other variants is also quite useful for the investigation because with any priority rank the expert conclusion contains the information about which of the groups of indications and actual data these disagreements relate to (see Fig 1).

In entering inspectorial data into the computer the invertigator is provided with an opportunity for making help requests to get a reference information stored in the computer memory (comments, schemes, photos) which assists the operator to correctly form a set of indications characterizing the status of a piece of machinery.

The use of the expert-examination computer system permits developing the measures aimed at improving the reliability of technical equipment and prolonging its life with the use of the methods of metallographical analysis of failed parts.

The scientific and methodological base, experience in practical investigations and multifaceted reference information gathered in the system enable it to be used as a learning system for training specialists in the field of diagnosing machine parts and structures.